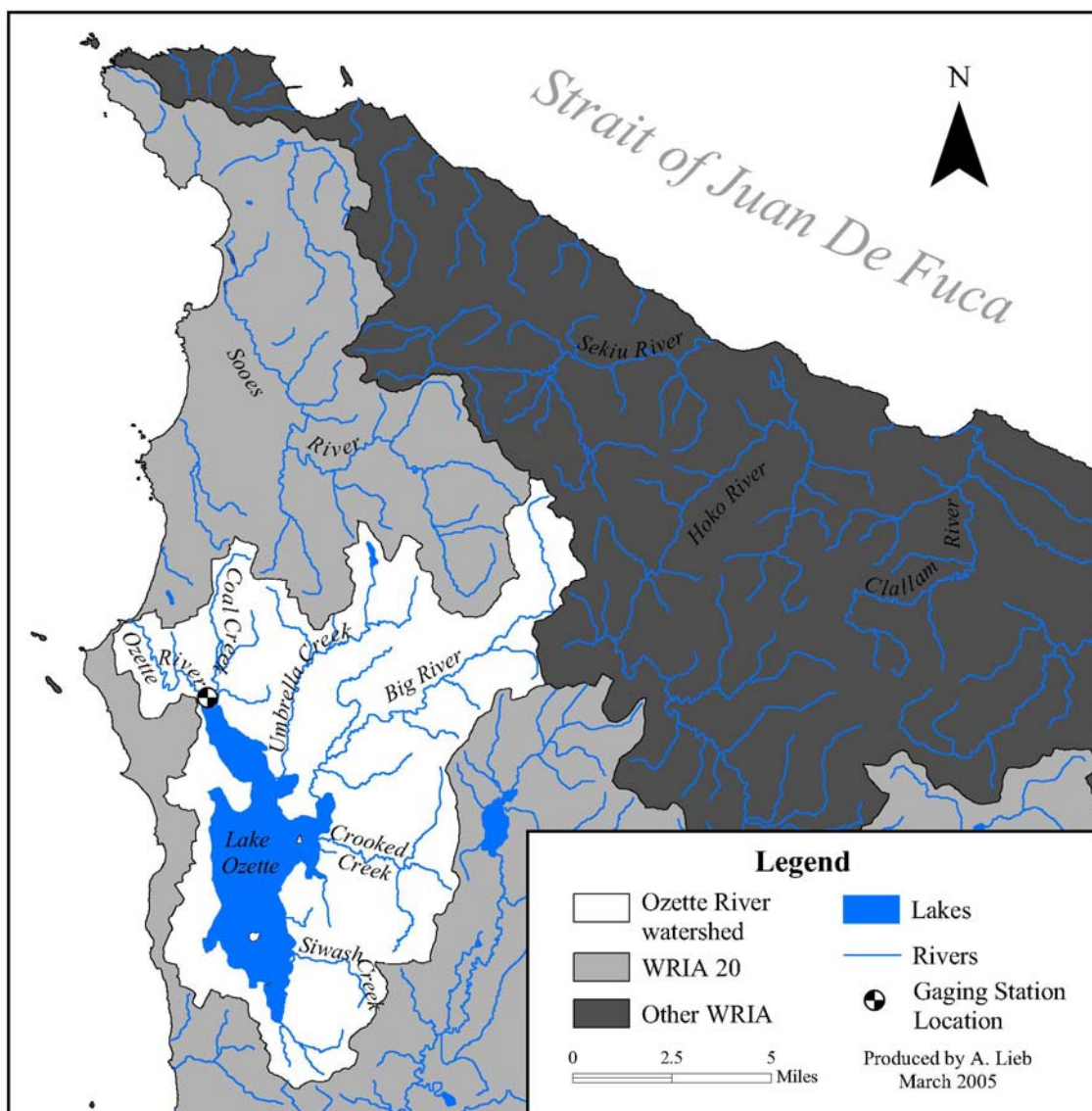


## Ozette River watershed

The Ozette River is a major stream drainage on the western edge of the Olympic Mountains that drains into the Pacific Ocean. The entire drainage area measures 88 square-miles, and the outflow from Lake Ozette marks the beginning of the Ozette River. The Ozette River watershed encompasses approximately 7.4 percent of WRIA 20, and is located on the northern part of WRIA 20. Figure 28 below illustrates the location of the Ozette River watershed within WRIA 20.

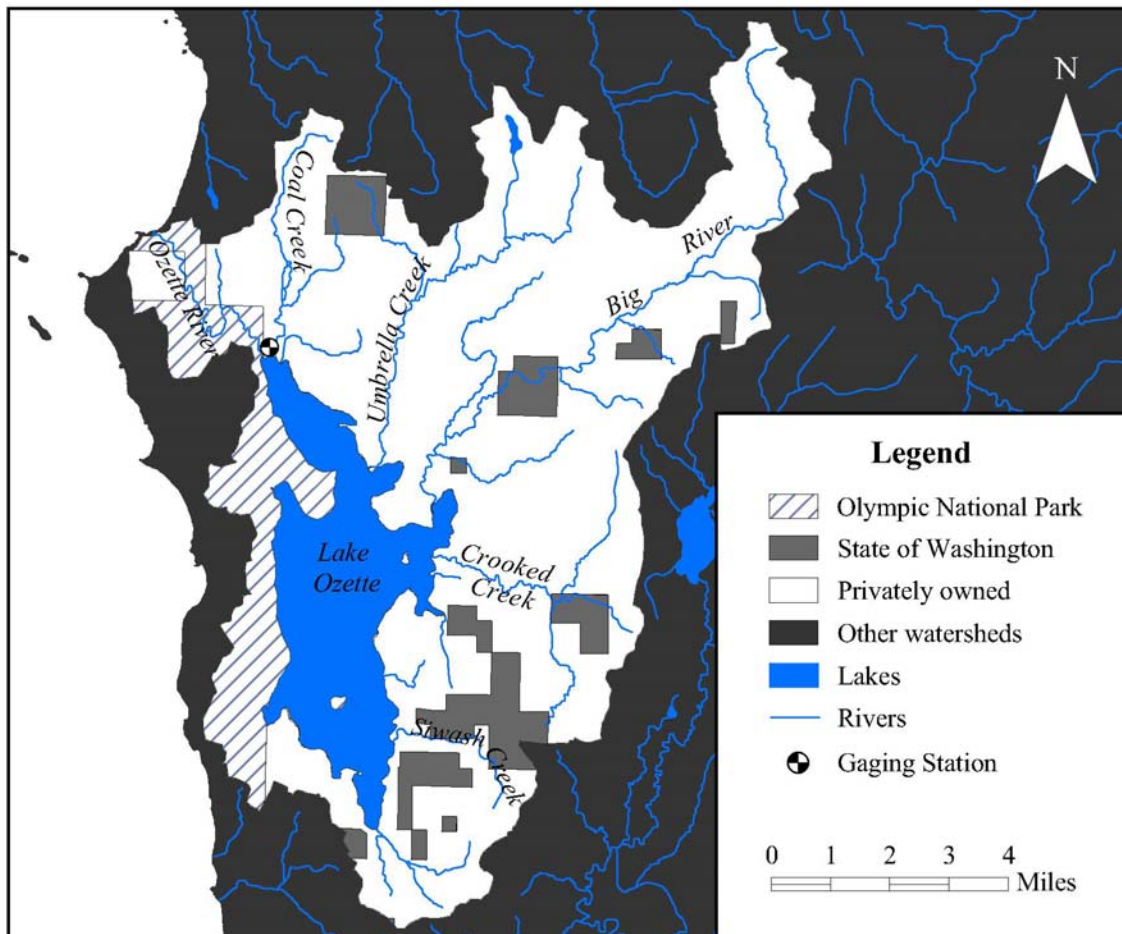


**Figure 28.** Location of Ozette River watershed.

## Watershed Conditions and Flow Evaluations Ozette River watershed

The Sooes River basin is located to the north, and the Dickey River basin, within the Quillayute River watershed, borders the Ozette River basin on the South. The Ozette headwaters from Big River are located east of the Hoko River drainage, which is location within WRIA 19.

Elevation of the Ozette River watershed ranges from over 1950 ft at Sekiu Mountain down to sea level at the outlet. Average annual precipitation is highest along the eastern watershed edge, reaching over 130 inches per year at the headwaters, and decreases to the west with the lowest values of less than 73 inches per year occurring along the southwest edge of the drainage. The southeastern portion of the watershed lies within the Olympic National Park, which includes the area of Lake Ozette. The remaining drainage basin is either administered by the State of Washington or is privately owned. The administrative areas for the Ozette River water are illustrated in Figure 29, and Table 57 summarizes the Ozette drainage areas by land management.

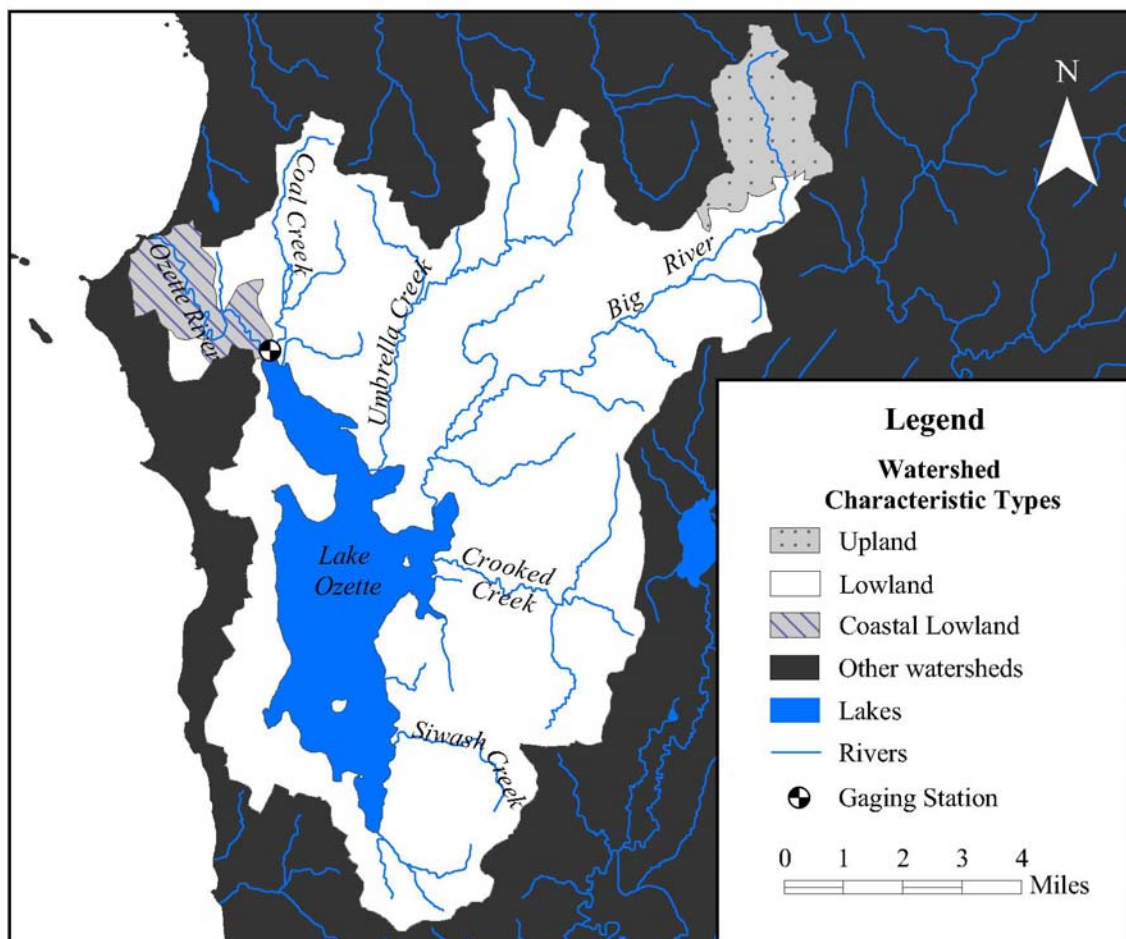


**Figure 29.** Land Administration within the Ozette River watershed.

**Table 57.** Land administration within the Ozette River watershed.

Land Administration	Area (sq. mi.)	Percent of Total Area
Olympic National Park	8.4	9.6
Lake Ozette (Olympic National Park)	11.6	13.2
State of Washington	6.8	7.7
Privately owned	61.2	69.5
Total Area	88.0	100

The Ozette River basin is dominated by lowland areas, with only a small upland area at the headwaters of Big River. Upland areas generally begin near 600 ft above sea level and extend to less than 3200 ft. Upland areas are either located below the average snow line or the snow usually melts within a short period of time. Upland areas contribute large portions of streamflow during winter precipitation months. The transition from upland to lowland subwatershed areas is illustrated on the watershed characteristics map, Figure 30, below.



**Figure 30.** Watershed Characteristics of the Ozette River watershed.

## Watershed Conditions and Flow Evaluations Ozette River watershed

Lowland areas begin near 200 ft above sea level and extend only to 1300 ft, as described by the watershed characteristics method. These areas provide additional streamflow during the winter precipitation months with similar precipitation patterns as the upland areas. Precipitation that falls within lowland subwatersheds is more likely to be lost to subsurface water levels, especially within valley bottoms. When valley floors are expansive and flat, a larger portion of precipitation is lost to interception, evapotranspiration, and ground water, so these areas are considered ineffective towards surface water streamflow. These ineffective areas are characterized as coastal lowland areas and begin at sea level and extend only up to 400 ft in elevation. Coastal lowland areas function very similar to lowland area, but the amount of additional precipitation that is captured in this drainage area is nearly equivalent to the amount of water lost to ground water. Therefore, coastal lowland areas are essentially ineffective in entirety to surface water flows. A small coastal lowland subwatershed is found in the most downstream portion of the Ozette River watershed, and this area was considered ineffective to streamflow when precipitation was low. Table 58 below summarizes the area of the Ozette River watershed characterized by each subwatershed type.

**Table 58.** Watershed characteristics of areas within the Ozette River watershed.

Watershed Characteristics	Area (sq. mi.)	Percent of Total Area
Upland	3.9	4.5
Lowland	69.4	78.8
Coastal Lowland	3.1	3.5
Lake Ozette	11.6	13.2
Total Area	88.0	100

### ***Streamflow Evaluations of the Ozette River***

Streamflow histories were determined for several locations within the Ozette River watershed. Two of these locations were on tributaries to Lake Ozette:

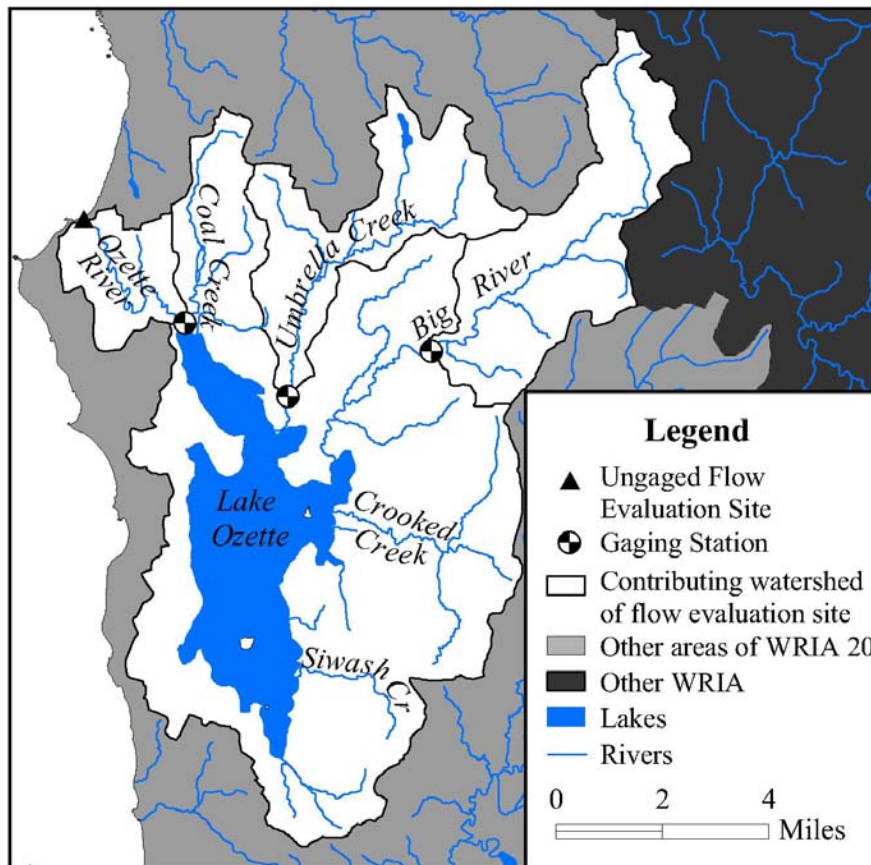
- Umbrella Creek at Hoko-Ozette Road Bridge
- Big River at 27E Big River Bridge

The final two locations are downstream of Lake Ozette:

- Ozette River below Coal Creek
- Ozette River at the ocean outlet

The locations of these sites are illustrated in Figure 31.





**Figure 31.** Locations within the Ozette River watershed where natural flows were developed.

As indicated in Figure 31, streamflow measurements were collected on the Lake Ozette tributaries of Big River and Umbrella Creek, but these measurements were by the Makah Indian Tribe, rather than the USGS. The Big River gage began operation in November 2003, and the Umbrella Creek gage began operation in October 2004. An extended synthetic period of record was generated for each between October 1961 and September 1999 through the use of regression techniques comparing these gaged measurements against USGS gaging station 12043300, Hoko River near Sekiu, which is still in operation.

The main stem Ozette River posed unique challenges for determining flow frequencies. Most importantly, the storage effects of Lake Ozette needed to be accounted for in Ozette River streamflow estimates. Since the Ozette River is affected by such a large lake, a different methodology was used to estimate streamflow frequencies for the Ozette River below Coal Creek than was used in other WRIA 20 watersheds. This methodology, as well as how data was developed for the Ozette River at ocean outlet, are described in Appendix 2.

## **Watershed Conditions and Flow Evaluations**

### **Ozette River watershed**

The primary USGS gaging station used to develop Ozette River streamflow histories is the Ozette River at Ozette (#12043150), which has been discontinued since 1979. This gage has a continuous daily record between August 1976 and October 1979. Ozette River streamflow data was also derived from recorded lake levels in Lake Ozette collected by the National Park Service between November 1981 and September 1999, as well as stage-discharge rating information collected by the Makah Indian tribe.

Although the watershed characteristics method was not utilized in the Ozette River watershed, a summary of the areas within each watershed characteristic type designated by contributing watershed is described in Table 59. Also, the average annual precipitation values that could be used to weight streamflow in the watershed characteristics method are summarized in Table 60.

The variability of streamflow at each of these locations is described in detail below. The provided graphs illustrate the expected variation of naturally occurring streamflow for each accumulated watershed area. The range in variation is illustrated in approximate average monthly flow in cubic feet per second (cfs), and these values are summarized in the corresponding table for each evaluation site. These values are estimated from how frequent a monthly total flow occurred in the period between October 1961 and September 1999.

## Watershed Conditions and Seasonal Variability for Select Streams within WRIA 20

**Table 59.** Watershed characteristics within each portion of the Ozette River watershed.

Watershed Characteristic Types	Big River above Makah gage (27E Big River Bridge)	Big River below Makah gage above Lake Ozette	Umbrella Creek above Makah gage (Hoko- Ozette Rd Bridge)	Umbrella Creek below Makah gage below Lake Ozette	Ozette River above Coal Creek	Coal Creek above Ozette River	Ozette River at outlet
	Area (sq. mi.)	Area (sq. mi.)	Area (sq. mi.)	Area (sq. mi.)	Area (sq. mi.)	Area (sq. mi.)	Area (sq. mi.)
Upland	3.91	-	-	-	-	-	-
Lowland	9.47	9.49	10.4	0.36	34.0	4.47	1.16
Lake Ozette (open water)	-	-	-	-	11.6	-	-
Coastal Lowland	-	-	-	-	0.030	-	3.08
Entire area	13.4	9.49	10.4	0.36	45.6	4.47	4.24

**Table 60.** Average annual precipitation of each portion within the Ozette River watershed.

Watershed Characteristic Types	Big River above Makah gage (27E Big River Bridge)	Big River below Makah gage, above Lake Ozette	Umbrella Creek above Makah gage (Hoko- Ozette Rd Bridge)	Umbrella Creek below Makah gage below Lake Ozette	Ozette River above Coal Creek	Coal Creek above Ozette River	Ozette River at outlet
	Ave Ann Precip (in)	Ave Ann Precip (in)	Ave Ann Precip (in)	Ave Ann Precip (in)	Ave Ann Precip (in)	Ave Ann Precip (in)	Ave Ann Precip (in)
Upland	123.3	-	-	-	-	-	-
Lowland	104.7	90.0	92.1	81.9	82.9	81.0	75.9
Lake Ozette (open water)	-	-	-	-	78.8	-	-
Coastal Lowland	-	-	-	-	77.4	-	74.9
Entire area	110.1	90.0	92.1	81.9	81.8	81.0	75.2

### **Big River at 27E Big River Bridge –**

The 27E Big River Bridge is located upstream of two additional Big River tributaries, Trout Creek and Dunham Creek. Precipitation averages range from 92 inches annually near the gage to over 130 inches annually along the northeastern ridge that separates the Ozette River watershed from the Hoko River watershed.

Streamflow information was collected at this bridge location by the Makah Indian Tribe starting on November 3, 2003 and is still being collected. Regression techniques were used to create a synthetic period of record for this location between October 1961 and September 1999. The synthetic record was developed using regression techniques on both daily and monthly streamflow data against the USGS gage 12043300, Hoko River near Sekiu. At low flow times, when average daily streamflow was less than 40 cfs in the Hoko River and 7 cfs in the Big River, a regression relationship of 49 concurrent measurements exhibited an  $R^2$  of 0.84. Thus, a regression equation was used to estimate Big River daily average streamflow from the Hoko River at low flow times. Monthly total streamflow in the Big River during low flow times was estimated by summarizing estimates of daily average flow in months where all Hoko River streamflow measurements were less than 40 cfs. Since 17 months in the Hoko River gaged record included only average daily flows below 40 cfs, 17 months of the Big River synthetic record were generated by first estimating daily average values and then summarizing these values to estimate total monthly flow in ac-ft. The remaining 439 months in the period of record were estimated through regression equations against monthly totals measured or estimated at the Hoko River gage. Of these 439 months, 261 months were estimated from gaged Hoko River monthly total streamflow, and 178 months were estimated from the estimated Hoko River values that were developed through regressions against other local streamflow gages, specifically:

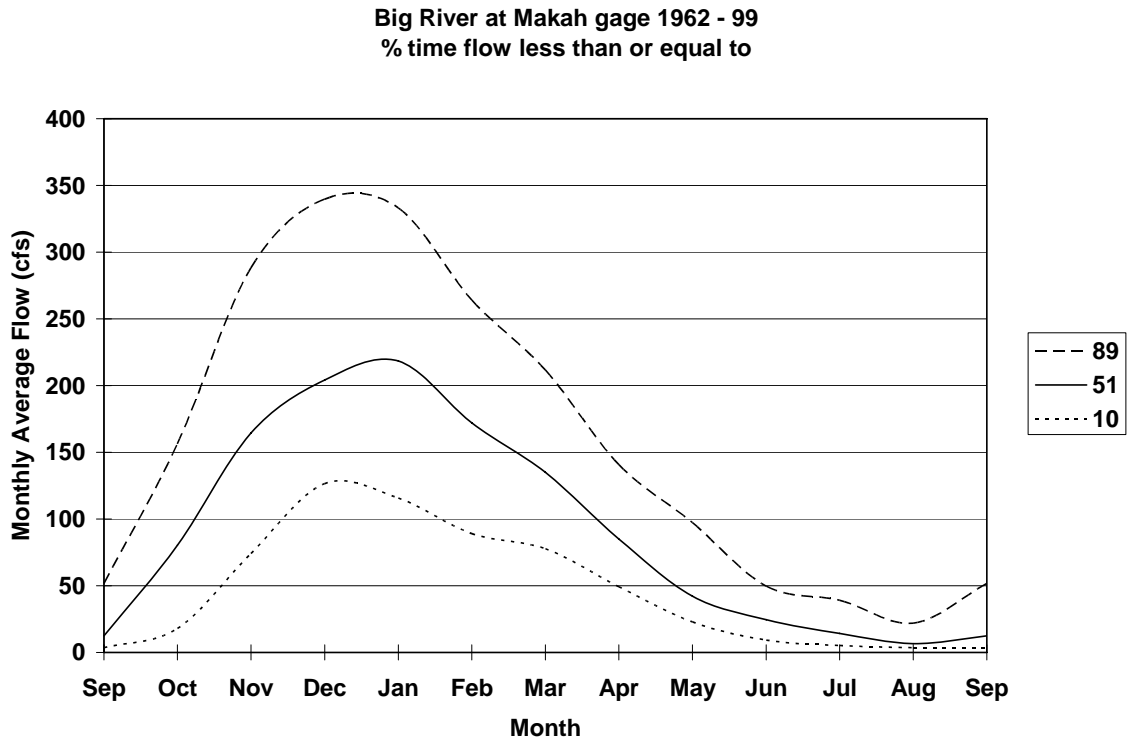
- USGS Station Number 12043100      Dickey River near La Push, WA
- USGS Station Number 12043163      Sooes River below Miller Creek near Ozette, WA
- USGS Station Number 12043000      Calawah River near Forks, WA
- USGS Station Number 12042800      Bogachiel River near Forks, WA
- USGS Station Number 12041200      Hoh River at U.S. Highway 101 near Forks, WA

Big River streamflow was only assessed at this gaged location, but the record developed for this gage located could be used to estimate streamflow at the outlet into Lake Ozette in future analyses through use of the watershed characteristics method.



## Watershed Conditions and Seasonal Variability for Select Streams within WRIA 20

Streamflow in the Big River exhibits the greatest variation during the winter season precipitation maxima, or specifically between the months of November and February. Streamflow recedes to minimum and baseflow levels during the summer months and typically extend into the early fall months of September and October.



**Table 61.** The percent of time that average monthly streamflow (cfs) in Big River at the 27E Big River Bridge is less than or equal to the indicated value.

Percent	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
89	156	288	340	333	264	212	141	97	50	39	22	52
51	80	165	204	218	172	135	85	42	25	14	7	12
10	18	74	126	116	89	78	49	23	9	5	3	4

### **Umbrella Creek at Hoko-Ozette Rd Bridge –**

Streamflow in Umbrella Creek has been measured by the Makah Indian tribe where the Hoko-Ozette Road crosses Umbrella Creek, less than 1 mile upstream from the outlet into Lake Ozette. Approximately 97 percent of the entire Umbrella Creek watershed contributes to streamflow at this location, thus there is likely little difference between streamflow measured at this location and at the outlet into Lake Ozette. Precipitation increases in a northeastern direction and varies between 81 inches annually near the gage to over 105 inches annually at the northeastern ridgeline that separates the Ozette River watershed from the Sooes River watershed.

The Makah tribe began collecting streamflow information at this location on December 18, 2003, and this gage is still in operation. Regression techniques were used to create a synthetic period of record for this location between October 1961 and September 1999. Regressions were created using daily and monthly streamflow information from other local streamflow gages operated by the USGS, specifically:

- USGS Station Number 12043300      Hoko River near Sekiu, WA
- USGS Station Number 12043163      Sooes River below Miller Creek near Ozette, WA

Low flow months were estimated from a regression equation that was developed by comparing daily average flow in Umbrella Creek and the Hoko River. Average daily streamflow in Umbrella Creek was estimated from gaged average daily flows in the Hoko River, and the summer months between 1962 and 1965 were calibrated using instantaneous streamflow measurements taken in Umbrella Creek. When the Hoko gage was not in operation, gaged streamflow measurements from the Sooes River were used to estimate spring and summer average daily flows in Umbrella Creek between 1976 and 1986. In these months, daily average flow in Umbrella Creek was estimated from equations that were developed by comparing several instantaneous streamflow measurements collected in 1976 by the USGS to the USGS Sooes River gage. The remaining months were estimated from the latest revised version of the Hoko River extended synthetic record that did not use the USGS gage on Dickey River. Instead, this extended record relied on streamflow measurements from:

- USGS Station Number 12043163      Sooes River below Miller Creek near Ozette, WA
- USGS Station Number 12043000      Calawah River near Forks, WA
- USGS Station Number 12042800      Bogachiel River near Forks, WA
- USGS Station Number 12041200      Hoh River at U.S. Highway 101 near Forks, WA

## Watershed Conditions and Seasonal Variability for Select Streams within WRIA 20

Table 62 summarizes the methods used and the percent of the final synthetic record developed through each source or methodology.

**Table 62.** Methods used to develop final synthetic period of record for Umbrella Creek at the Hoko-Ozette Rd Bridge (at the Makah streamflow gage).

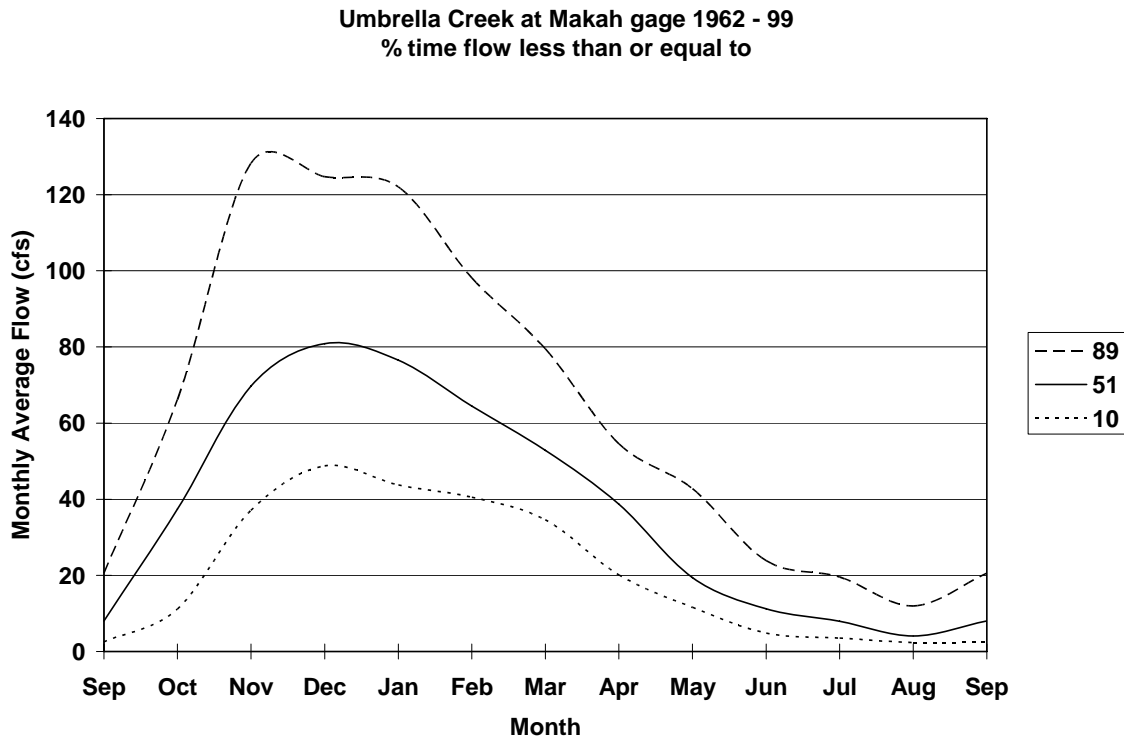
Source/Method	Number of Months	Percent of Period of Record
Estimated daily streamflow using regression equations against daily streamflow in Hoko River gage	119	26.1%
Estimated daily streamflow using regression equations against daily streamflow in Sooes River gage	39	8.6%
Estimated monthly streamflow using regression equations against Hoko River gage	144	31.6%
Estimated monthly streamflow using regression equations against Hoko River estimates derived from Sooes River gage	69	15.1%
Estimated monthly streamflow using regression equations against Hoko River estimates derived from Calawah River gage	58	12.7%
Estimated monthly streamflow using regression equations against Hoko River estimates derived from Hoh River at Highway 101 gage	15	3.3%
Estimated monthly streamflow using regression equations against Hoko River estimates derived from Bogachiel River gage	12	2.6%
Total number of months	456	100%

A previous draft version of these Umbrella Creek estimates was provided to the WRIA 20 planning group in early May 2005. A later review of these estimates uncovered an error in the estimation process and thus prompted an update of the erroneous estimates. The following graph illustrating streamflow variation in Umbrella Creek has been updated to reflect these new estimates, but the WRIA 20 group asked for the original draft to be included in this report. As such, the draft estimates originally provided to the WRIA 20 planning group has been included in Appendix 2.

Streamflow in Umbrella Creek is similar to that seen elsewhere in WRIA 20, especially in the Big River, which is also a tributary to Lake Ozette. The months of greatest streamflow variation are typically between November and February, while streamflow receded to minimum or baseflow levels between the summer

**Watershed Conditions and Flow Evaluations**  
**Ozette River watershed**

months of June and September. Baseflow levels typically cease in October each year, when precipitation increases in the fall.



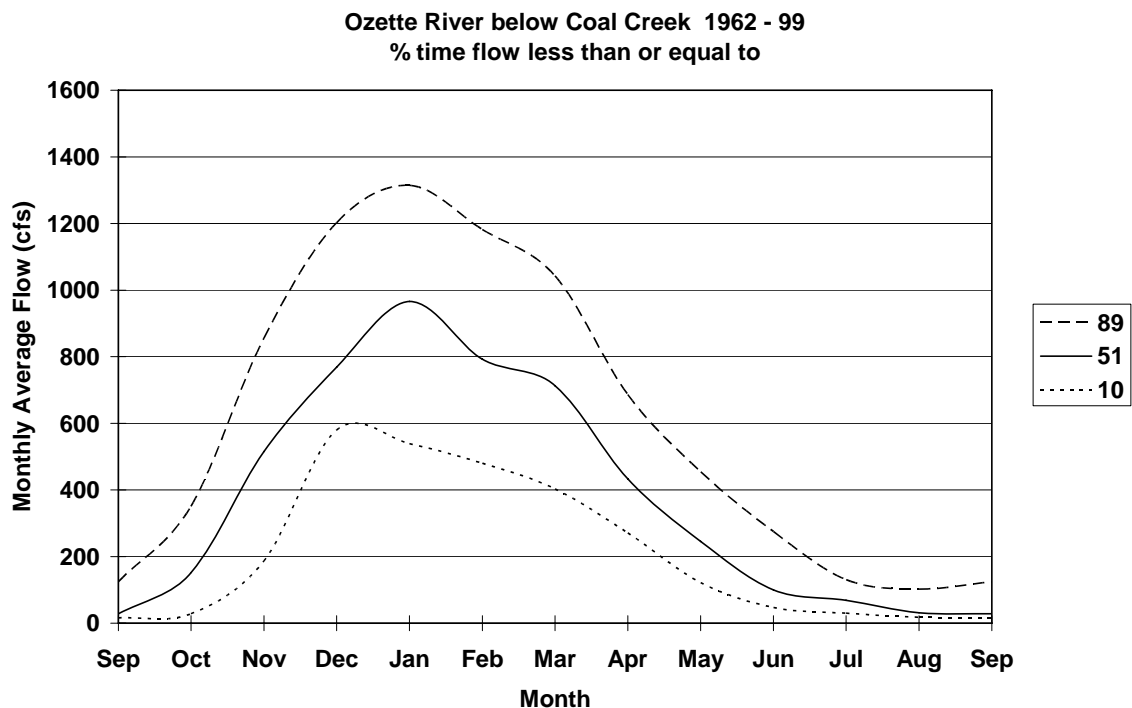
**Table 63.** The percent of time that average monthly streamflow (cfs) in Umbrella Creek at the Hoko-Ozette Rd Bridge is less than or equal to the indicated value.

Percent	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
89	109	199	224	208	180	148	96	56	24	20	12	21
51	53	114	140	146	117	91	56	25	13	8	4	7
10	9	57	91	76	59	55	29	14	5	4	2	2

### Ozette River below Coal Creek –

Coal Creek outflows into the Ozette River about 325 feet downstream of the outlet of Lake Ozette. The river basin covers approximately 83.7 square-miles in drainage area and is mainly owned and administered by private timber companies, thus active timber removal has likely occurred. The methodology used to estimate the Ozette River below Coal Creek is described in Appendix 2.

During the late summer, flow in the Ozette River recedes to minimum flow and occasionally extends into October. The months between November and March exhibit the greatest indicated variation in streamflow. The variability exhibited in February and March is greater than the variability estimated for other WRIA 20 watersheds. The cause of this heightened variability is due to the storage effects of Lake Ozette, which fills up and provides a natural regulation on streamflow being released. In essence, the storage effects of Lake Ozette allow higher outflows to be sustained for a longer period of time than compared to upland-lowland watersheds that do not contain a lake, which directly release winter precipitation into streams and groundwater as it falls from precipitation.



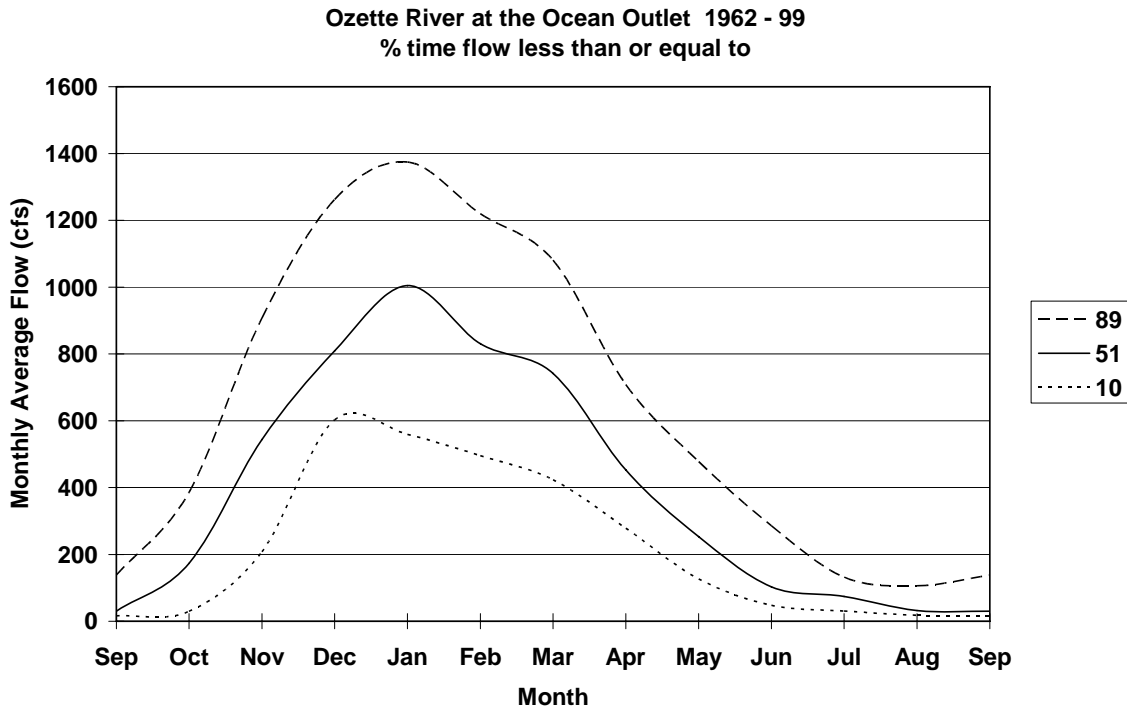
**Table 64.** The percent of time that average monthly streamflow (cfs) at the Ozette River below Coal Creek is less than or equal to the indicated value.

Percent	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
89	351	856	1203	1315	1182	1043	686	454	275	131	102	125
51	152	515	769	966	793	713	433	246	100	69	32	28
10	28	187	580	539	480	403	271	121	47	30	18	16

### **Ozette River at the Pacific Ocean Outlet –**

An additional 4.3 square-miles of drainage area contributes to streamflow in the Ozette River below Coal Creek. This area is characterized mainly as coastal lowland due to the low elevations and large, flat expanses of land. This coastal lowland area includes 72.8 percent of this remaining drainage area and was considered to directly contribute additional streamflow only in months of high precipitation. The remaining 27.2 percent of the drainage is characterized as a lowland subwatershed, which drain into two unnamed tributaries. These lowland areas contribute directly toward streamflow throughout the year.

Seasonal maxima in streamflow are clearly shown for the winter season precipitation maximum. During the late summer and into the fall, flow in the Ozette River recedes to minimum flow. Similar to the flow upstream below Coal Creek, this minimum flow season is indicated to occasionally extend into October. Again, the months between November and March exhibit the greatest indicated variation in streamflow, which is longer than most lowland subwatersheds in WRIA 20 because of the storage effects of Lake Ozette.



**Table 65.** The percent of time that average monthly streamflow (cfs) at the ocean outlet of the Ozette River is less than or equal to the indicated value.

Percent	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
89	385	907	1262	1375	1220	1081	708	478	285	132	106	138
51	173	544	809	1004	830	742	453	253	103	74	32	30
10	29	208	603	559	496	423	278	126	48	30	18	16